

# Holographic Conformal Field Theories

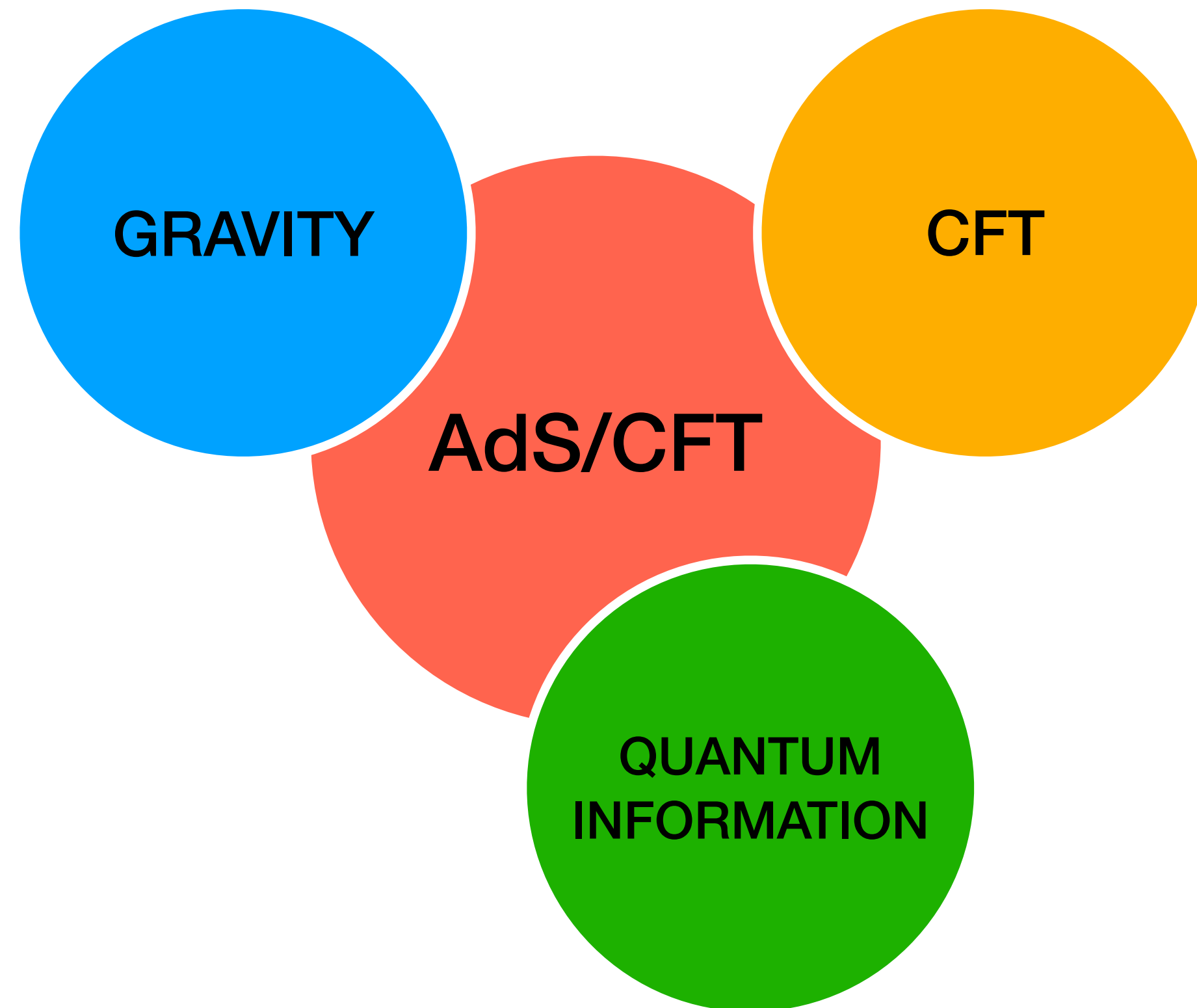
Federico Galli  
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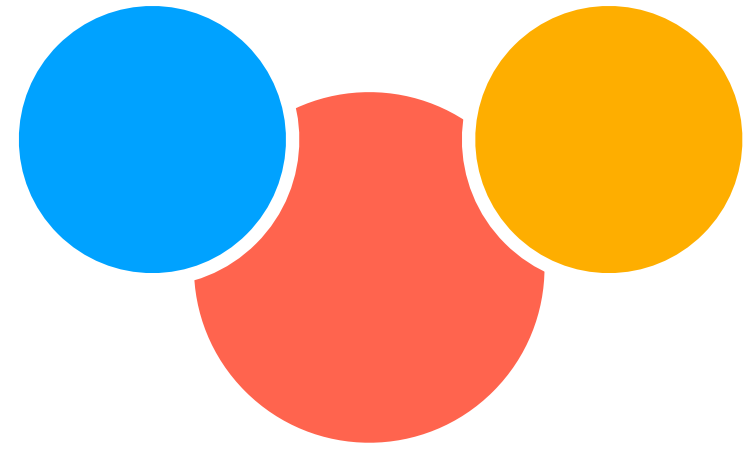


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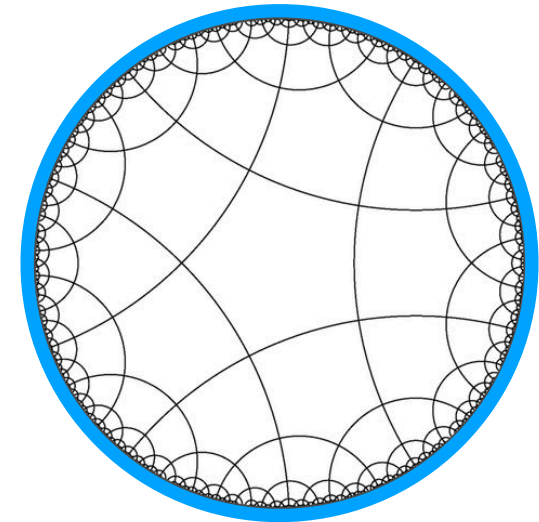
30 May, 2022 — Fellini General Meeting, Ferrara

# Context

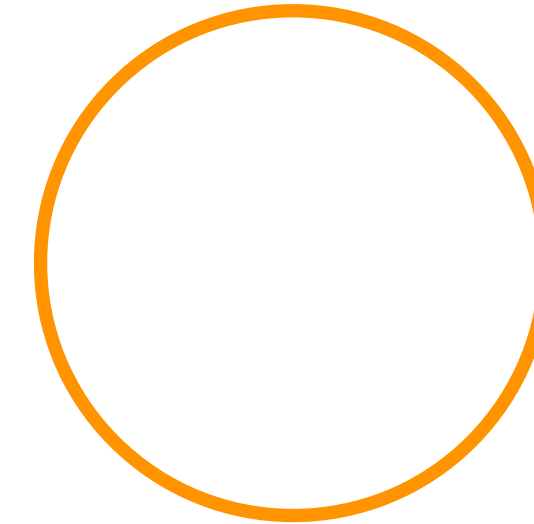




AdS/CFT Duality: mathematical equivalence between two theories



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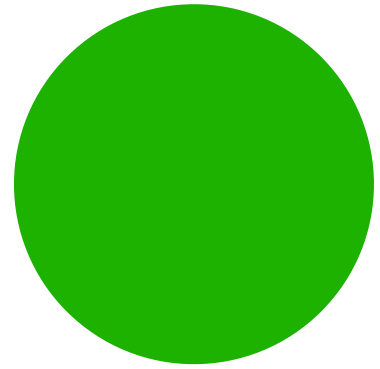


Gravity in Anti-DeSitter  
space-time in  $d+1$   
dimensions

Conformal Field Theory  
in  $d$  dimensions

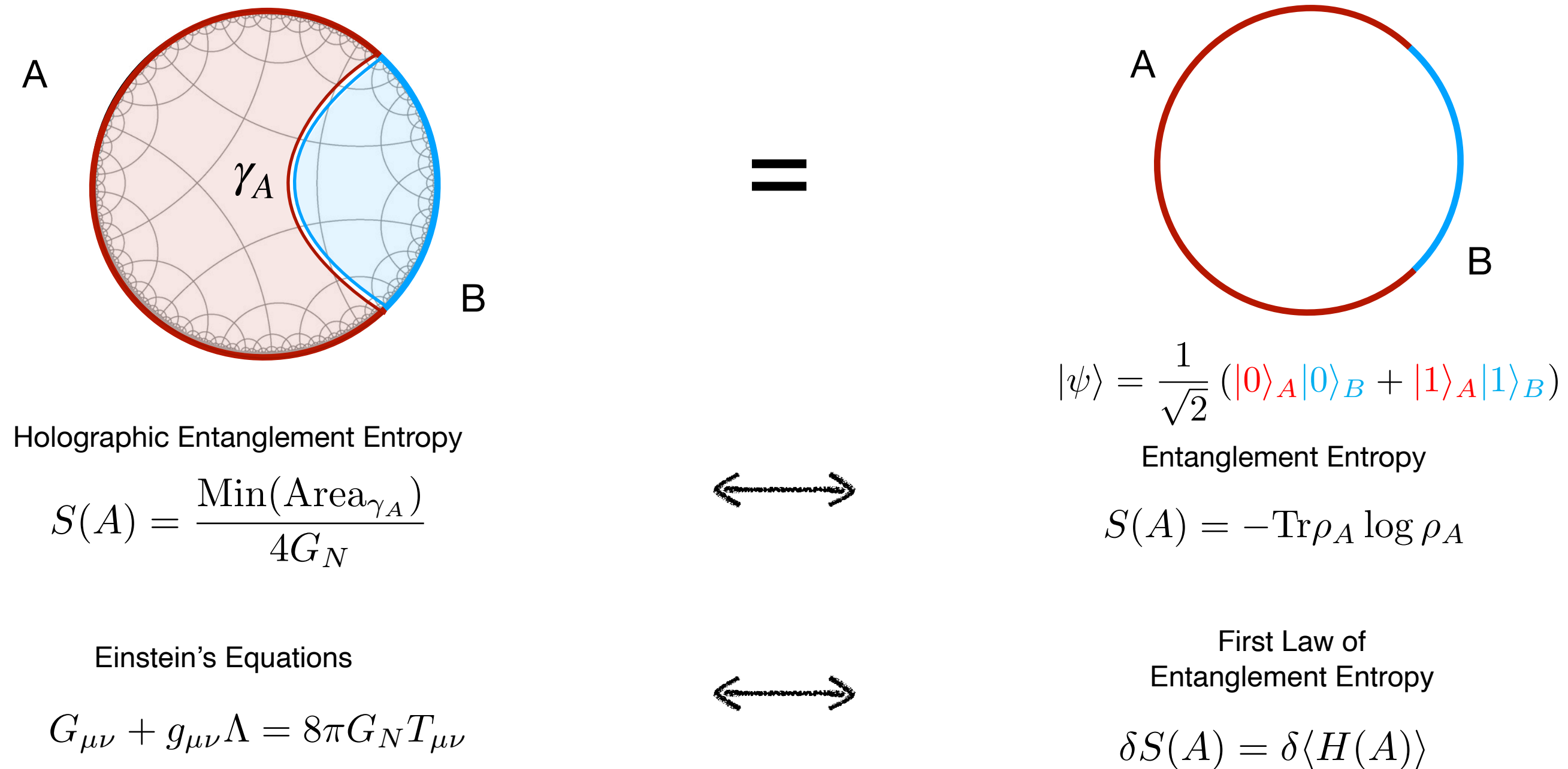
**Holography:** quantum gravity and spacetime are emergent, resulting from the collective behaviour of underlying non-gravitational degrees of freedom

How gravity and spacetime geometry are encoded in the dual holographic CFT degrees of freedom?



**Quantum Information:** powerful language and organizing principle to better understand gravity and quantum field theory

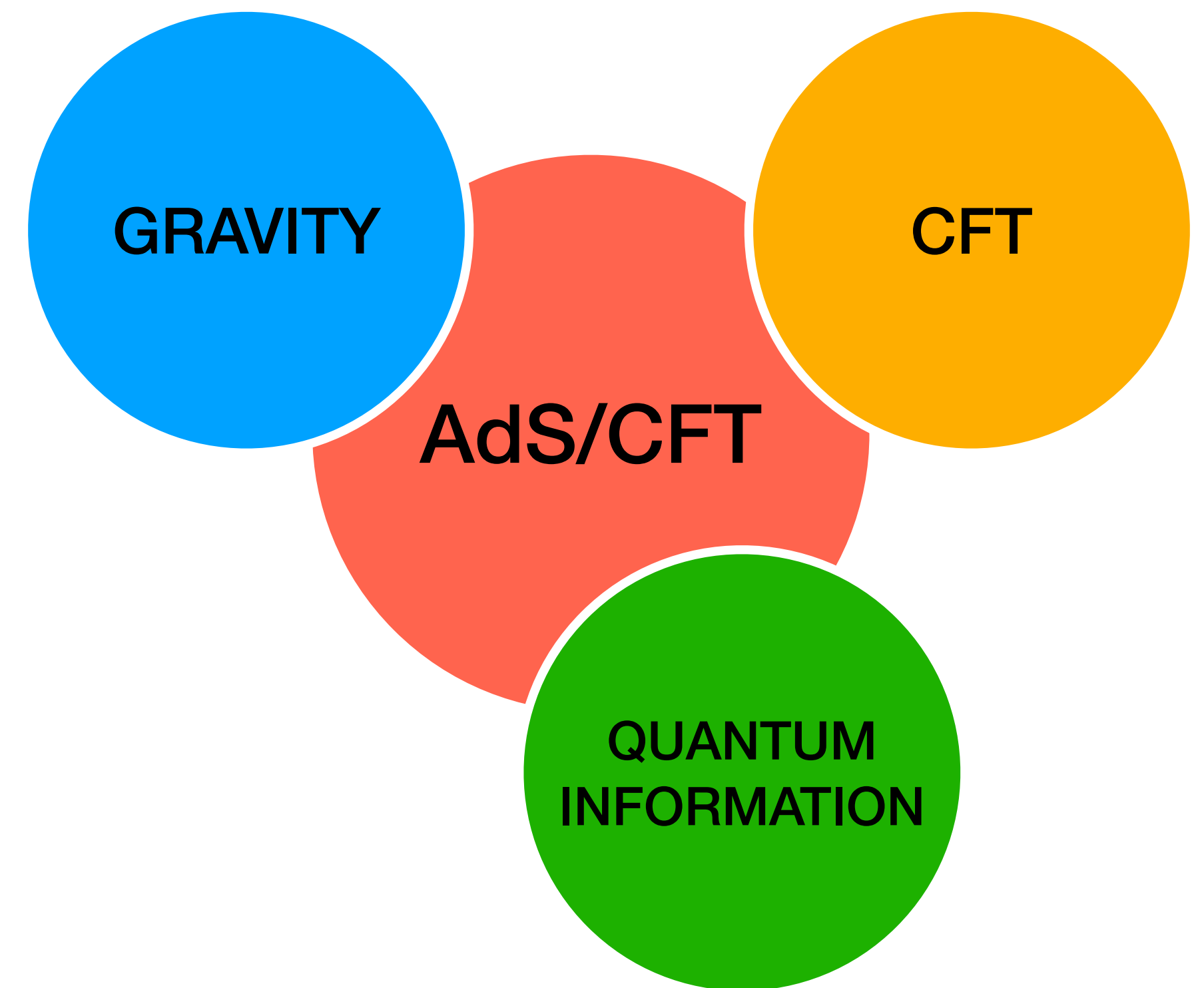
Concrete connection between spacetime geometry and entanglement



**Spacetime geometry from entanglement**

## How holographic spacetime emerges from the underlying non-gravitational degrees of freedom?

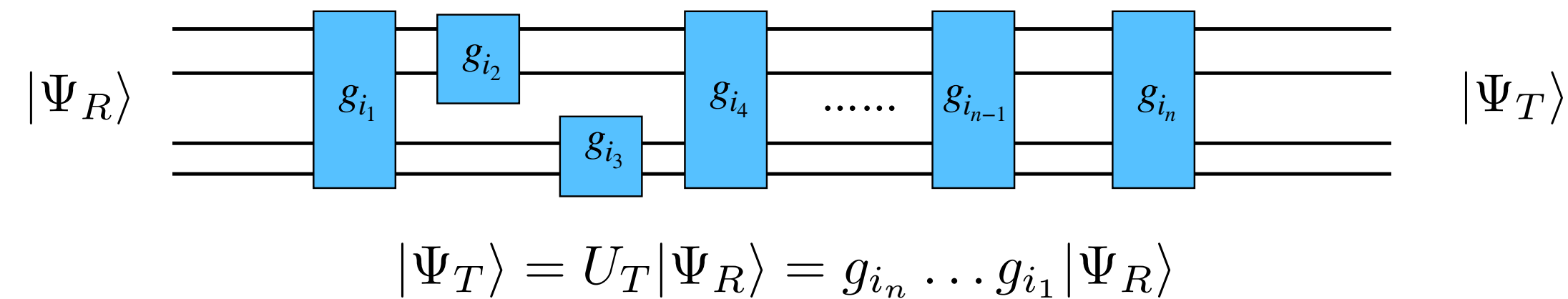
- Explore further the interplay between quantum information and holography
- Understand the structure of quantum correlations in states of CFT with a gravity dual
- Characterize CFTs that admit holographic dual and how they encode gravitational structures



# Quantum Circuit Complexity

w/ Bernamonti, Hernandez, Myers, Ruan, Simón  
w/ Bernamonti, Bigazzi, Billo, Faggi

Quantum circuit complexity: cost of the optimal circuit connecting a target and reference state through the action of unitaries

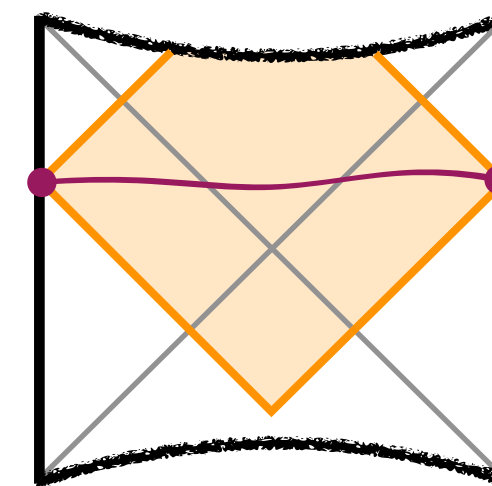


Complementary characterization of states next to entanglement entropy

Expected to have an important role in the program of reconstructing spacetime from entanglement (e.g. black hole interior)

Different gravitational observables proposed to compute complexity. Various attempts to define complexity in field theory.

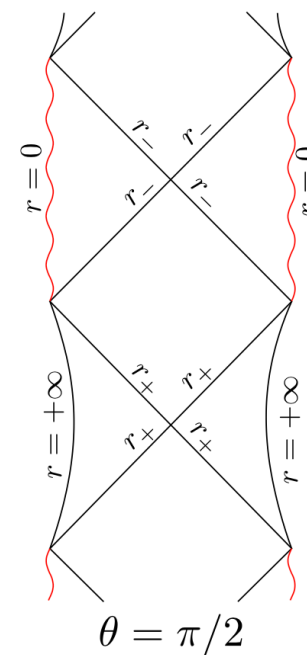
Systematic understanding still lacking



$$\mathcal{C} = \text{Min} \int_0^1 ds F(x^a, \dot{x}^a)$$

# Quantum Circuit Complexity

- Complexity of states with rotation: rich structure and interesting limits where to test different measures



- Better understanding of the gravitational observables associated with complexity
- Critical rotation velocity, high T limit: qualitative agreement between gravitational and field theory complexity measures

[Bernamonti, Bigazzi, Billo, Faggi, FG JHEP '21]

- First law of complexity: how complexity varies under a small change of the target state

$$\delta C = p_a \delta x^a \Big|_{s=1} + \frac{1}{2} \delta p_a \delta x^a \Big|_{s=1}$$

- Better understanding of the space of holographic states
- Guiding principle to compare different complexity measures and their relation

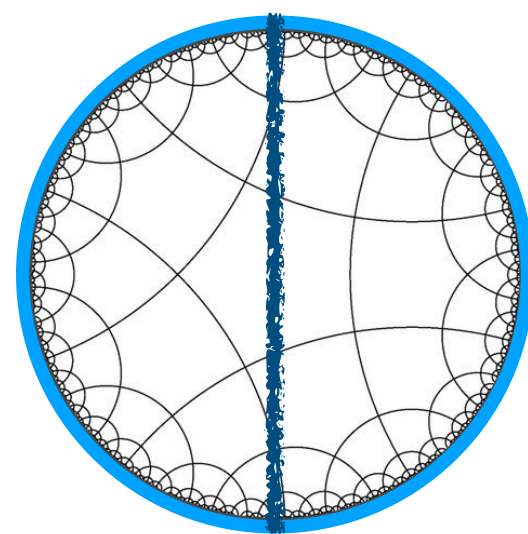
[Bernamonti, FG, Hernandez, Myers, Ruan, Simón PRL'19 & JPA'20]

# Doubly holographic models and entanglement islands

2019: new proposal for how entanglement entropy is evaluated in gravitational systems.

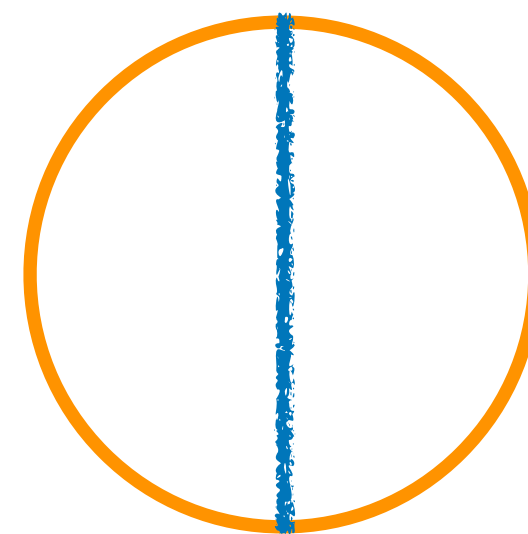
Important consequences for our understanding of aspects of the black hole information paradox!

For my project: new perspective on the understanding of the AdS/CFT correspondence



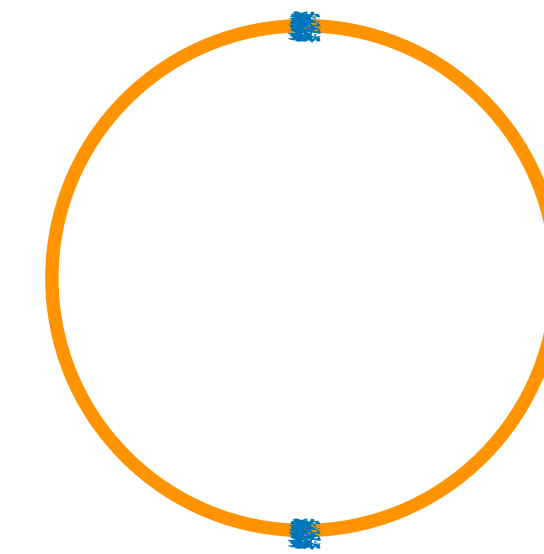
Fully gravitational

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Gravity + CFT

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Fully CFT

w/ Bernamonti, Emparan, Frassino — IN PROGRESS

Interdisciplinary secondment at ICS-CNR: quantum mechanical models that give and emergent notion of classical gravity. Different approach and context, but same fundamental questions.

Ongoing discussion w/ Coppo, Pranzini, Verrucchi



**Thank you!**